Measuring the Vortex Charge

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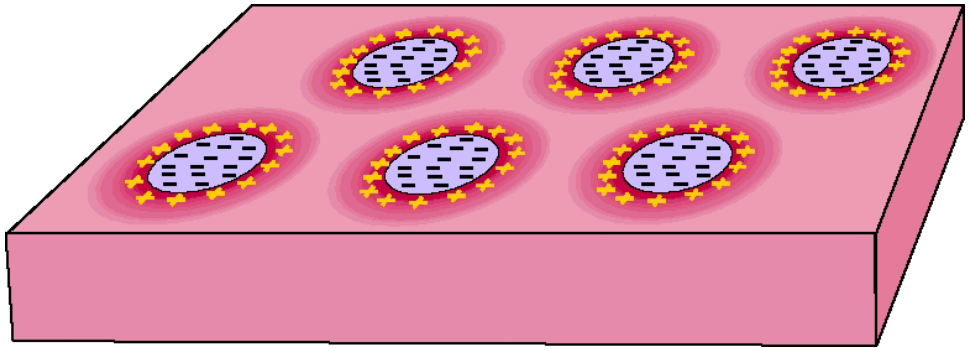
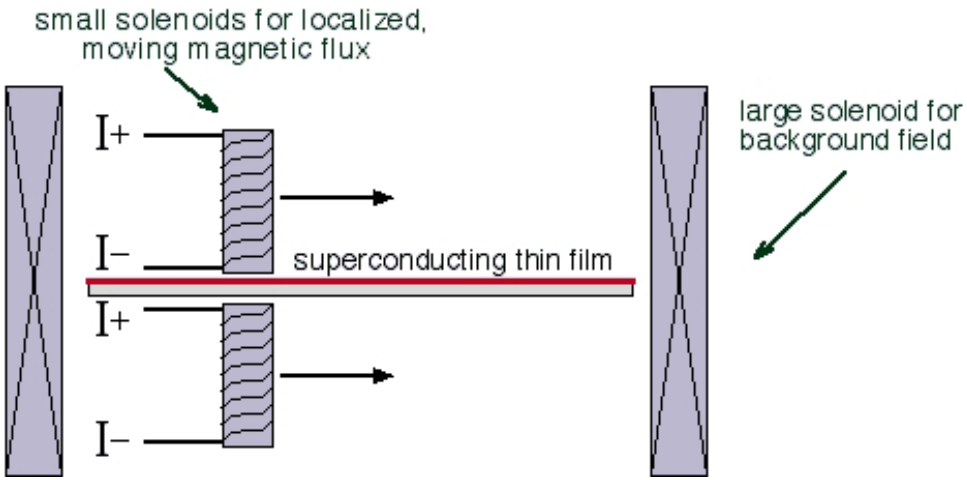
The amount of the electric charge deficit inside the core of a vortex in a superconductor depends strongly on the nature of the superconductivity. In the standard Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity, only an immeasurably small charge difference should arise. Many alternate theories of the high-temperature superconductors predict that a bigger charge imbalance exists between the center of the vortex and the region outside. The vortex charge has not yet been measured in any superconductor because the vortices are so small, the superconductor short-circuits the electric fields, and the charge difference is tiny.



Vortices in a Type-II Superconductor. Electric charge is expelled from the non-superconducting core of the vortex into the surrounding superconducting condensate. This project is measuring, for the first time, the amount of expelled charge.

Key Innovation:
two magnetic fields, no external current



If a vortex carries an electric charge, then a moving vortex carries an electric current. Certain experiments have always hinted that a vortex charge might exist, but extracting the contributions of the vortex effects from the measurement currents has always been a hurdle. The key to isolating the vortex contribution is the use of mobile flux. By mechanically driving the vortices, we create a current from the vortices themselves in the absence of any external currents. A homogenous background field allows us to circumvent the short-circuiting effect of the surrounding superconductor, and measure a voltage which can only be attributed to the moving charge in the vortex core.

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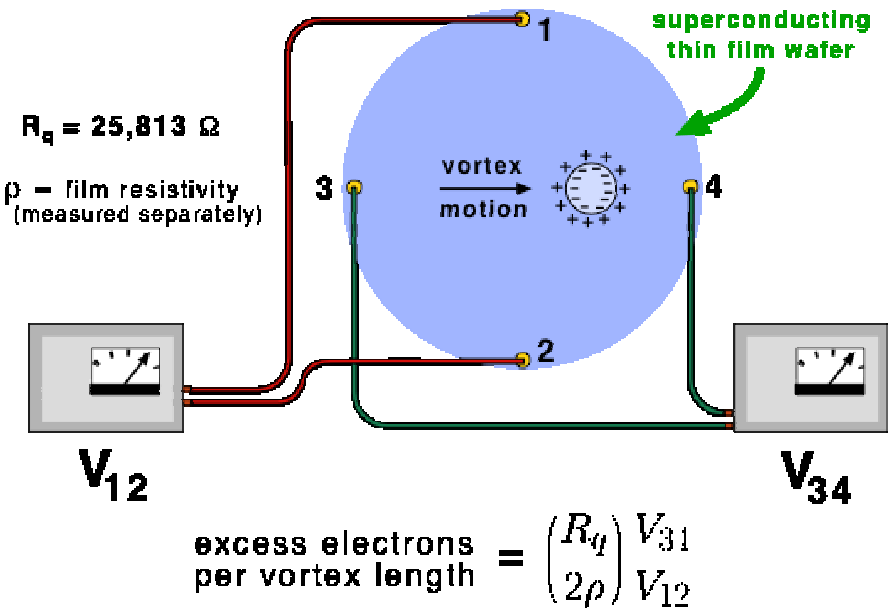
Ph.D. Candidate Thomas Fleming Fine-Tuning the Measurement Apparatus He Constructed to Measure the Vortex Charge

Absolute Calibration of the Experimental Results:



Educational Impact & Skills Acquired

- § Precision measurement
- § Nanovolt detection
- § Mechanical, electrical and cryogenic design
- § Data acquisition
- § Superconductivity

"Measuring the Charge of Magnetic Vortices in Type-II Superconductors: Experimental Design and Data Analysis"

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